THE IMPERIAL SOCIETY
FOR PROMOTING RUSSIAN COMMERCIAL
SHIPPING.

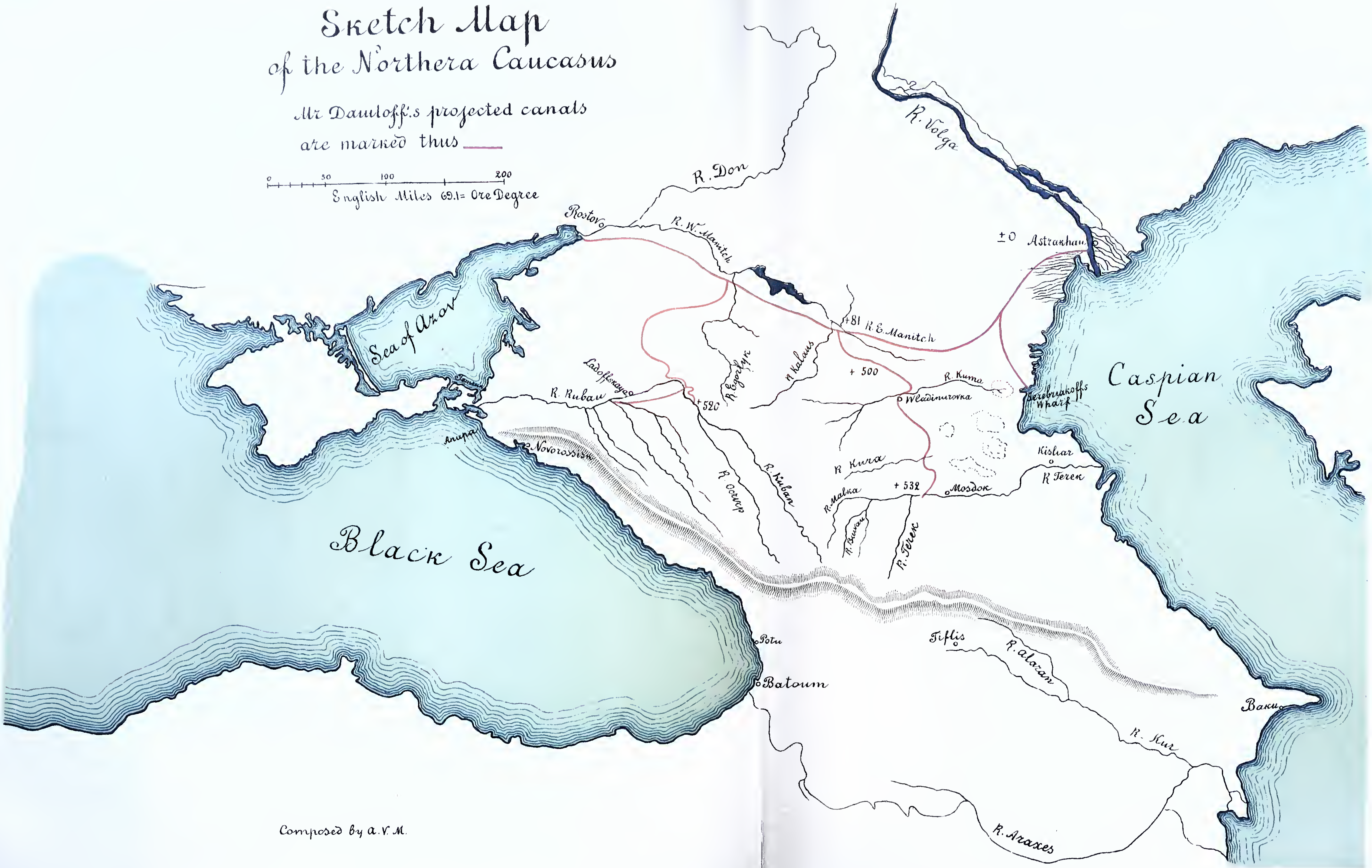
THE BLACK SEA
&
CASPIAN CANALS

BY M. A. DANILOFF, C. E.
Fellow of the Imperial Society for promot. Russ. com. shipping.

TRANSLATED FROM THE RUSSIAN BY
A. VON MECK.

Short historical introduction.
Techincal discription.
Conclusion.

MOSCOW.
Printing offices of E. Liessner & J. Romahn,
Vosdvigenka Street, Krestovosdvigenski Per., house E. Liessner.
1893.



Sketch Map of the Northern Caucasus

Mr Danloff's projected canals are marked thus

Composed by A. V. M.

Лит. Рихтеръ, Москва.

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Дозволено цензурою. Москва, 16-го декабря 1892 года.

This short description of Mr Daniloff's project has been compiled from a lecture delivered by him before the General Assembly of the Imperial Technical Society on the 4|16 Sept. 1882. A table has been adjoined to facilitate the conversion of Russian measures into their English equivalents.

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A projected Canal System for the Northern Caucasus.

In 1878 I had the opportunity of making myself acquainted with the vast canal system of India which is carried out on the two great principles of navigation and irrigation. Thus it occurred to me that a similar system of canals would be of infinite benefit to the Northern Caucasus, and, in the event of the project being carried into execution, the engineering difficulties would be easily surmounted.

As I had carefully studied the state, physical and general, of the Northern Caucasus in 1868, at the time when investigations were being made for the projected line of railway to connect Aksai with Vladikavkas, via Piatigorsk, the feasibility of the construction of a system of canals in the Caucasus struck me very forcibly. We see the great benefits resulting to India from such a system, where vast tracts of desert have been, by artificial means, converted into rich and fertile plains, providing subsistence for great numbers of people, and where the canals afford means, not only of irrigation, but also of transit. Therefore why not endeavour to reclaim the great plains lying between the fine rivers Volga and the Don and Terek. These plains, instead of being reclaimed are, on the contrary, becoming more extensive owing to the scarcity of moisture resulting from the wholesale destruction of the forests on the northern slope of the Caucasian chain. Referring back to my previous statements respecting India, and to my knowledge and personal acquaintance with the general condition of the Northern Caucasus, I would advisedly suggest the irrigation of the vast plains of the Government of Stavropol, and of the Kuban and the Terek territories. But before undertaking the technical investigations I had studied the literary aspect of the question.

We are assured by an old tradition, that a water-way actually existed in the Northern Caucasus, and this assurance urged many energetic men to endeavour to establish a connection between the Black and Caspian Seas. In 1568 the Tartar Sultan Selim II. attempted to cut a canal between the rivers Volga and Don. Later on, the great Reformer of Russia, Peter the Great, conceived a plan for the construction of such a canal.

But the academician Pallas was the first to indicate the lowlands of the river Manytch as the direction in which should be carried a connecting Canal between the Black and Caspian Seas. Since that time the attention of all explorers and projectors has been directed to this valley, which is now but seldom visited by migrating heards of cattle and sheep. A whole century has elapsed since Pallas made his suggestion, bringing us up to the period of my own investigations. The reason for this neglect is to be found in the opinion expressed by some competent persons, who strongly doubted the possibility of constructing canals in this place for navigation purposes. As would be naturally expected, public opinion followed the lead of specialists, and the idea was abandoned as impracticable. I shall not attempt to enumerate the various projects, which have been formed since the suggestion of Pallas; but we must not omit to thank those who have supplied us with useful facts and figures. I refer to the trigonometrical levelling operations of 1837, which determined the difference of level between the Black and Caspian Seas. This was stated to be 83.76 feet; again we are indebted to the Kumo-Manytch expedition of 1860, which collected the most detailed and concise facts on the physical and topographical conditions of the Kumo-Manytch lowlands. One important fact was determined by this expedition, viz., that the valley of the Manytch has, at a point not far distant from the inflow of the river Kalaus, two distinct slopes. one, to the west, called the Western Manytch, in the direction of the Don, and which has a fall of 12 inches in the verst, and the other to the east, towards the Caspian, with a fall of 16 inches in the verst, close to the watershed, and further eastwards, 0.6 inch in the verst.

The levellings done by the Kumo-Manytch expedition showed that the highest elevation of the river's bed was at a place called, by the Kalmyks, Shara-Hullussun. the elevation at that spot being 11.569 sajens above the Black Sea level, and 24.379 sajens above the level of the Caspian. Close to this watershed is the island of Taikul, from whence I began my surveying operations eastwards and westwards. According to the levellings made by the Kumo-Manytch Expedition this point is 15,09 sajens above the Black sea level. Taking this as a basis the levellings made for me determined the elevation of the Caspian, near Serebriakoff's wharf, to be 12.54 sajens, or 87.78 feet below the level of the Black Sea.

From the same point the levelling operations were carried on up to the river Don, close to the village of Manytch, where at low water the mark registered + 0.75 sajens or 5.25 feet, and at high water it showed 2.48 sajens, or 17.36 feet above the level of the Black Sea.

All the projectors of a canal system in the lowlands of the Manytch fell into the great error of supposing that there would be sufficient water to construct a canal with a dividing point. But a more particular acquaintance with the locality proves the fallacy of this supposition, and clearly shows us the absolute necessity of the introduction of water from some outside source. I need scarcely say that sufficient water could have been provided had Mr Blum's plan been adopted. He proposed the cutting of a deep-sea canal similar to the Suez canal, between the Don and the Caspian. The length of this canal would have been some 700 versts, but the cost about 800,000,000 roubles.

However, after a careful study of the various schemes for the solving of this important question, I have come to the conclusion that, in order to connect the Caspian and Azoff seas, we would be obliged to supply the deficiency of water by special feeding canals from the rivers Terek and Kuban. These rivers possess two great advantages, and the most essential in the present case, firstly, that their fall is sufficiently considerable to carry the water to the highest dividing point of the canal; and, secondly, that in summer they carry down an enormous quantity of water owing to the melting of the mountain snows.

Every specialist who undertakes to seriously examine my statements will agree with me in saying that, without a supply of water from a foreign source the Canal cannot exist, and further that the rivers Terek and Kuban are the only rivers which can be utilised for such a purpose. Even the great Volga, owing to its comparatively low level must be excluded.

In planning the transversal section it was my aim to make as little excavations as possible, because the turning up of the soil in the Caucasus would, in all probability, cause intermittent fevers to prevail, the soil being impregnated with miasmatic germs. It would be only in the vicinity of the Manytch lakes that we should be compelled to make any considerable cutting, in order to bring the water of the canal to the required level.

The current of the projected canal has been calculated by means of Bazin's well-known formula, in which the dependency between the velocity (V), the inclination (I), the superficies of the canals section ω, and the perimeter of the section under water S, is expressed in the following manner,

$$V^2 = \frac{RI}{\alpha + \frac{\beta}{R}}, \text{ in which } R = \frac{\omega}{S}.$$

The coëfficient α, and β are, for earthwork slopes, equal to $\alpha = 0.000085$, and $\beta = 0.00035$.

A. The Rostoff-Astrakhan Canal.

In pursuance with the foregoing statements I would, first of all, propose to construct a navigation and irrigation canal between the mouths of the Don and Volga, close to the towns of Astrakhan and Rostoff. The transversal section of the canal to be constructed with burmes, and the slopes to be in the ratio of 2 to 1. The volume of water contained between the bottom of the canal and burmes is intended for the purposes of navigation, whereas the upper body of water, i. e. the volume from the burmes to the high-water level, will supply the irrigation to the surrounding country by means of small canals or feeding trenches cut out at intervals from the main stream, and above the various falls which occur in the main canal.

Its dimensions would be as follows:

a) from the Don to the island of Taikul.

Length	362.2	versts.
Transversal section:		
Width at bottom	63	feet.
Depth of water	10.5	„
Incline from 0.00003 to	0.000016	
Number of sluices, with a fall of 1.20 saj.	7	
Volume of water per second with a incline of 0,00003	3.52	cub. saj.

b) from the island of Taikul to the junction of the Astrakhan Serebriakoff canal:

Length	225.882	versts.
Transversal section:		
Width at bottom	63	feet.
Depth of water	10.5	„
Incline	0.00008	
Number of sluices, with a fall of 1.20 saj.	9	
Volume of water per second	5.85	cub. saj.

c) from the junction of the canals to Astrakhan.

Length	167	versts.
Transversal section:		
Width at bottom	70	feet.
Depth of water	10.5	„
Incline	0.000016	
Number of sluices, with a fall of 1.20 saj.	3	

The total length of this canal would thus be 755.082 versts.

B. The Terek Feeding-Canal.

Referring to the above-mentioned feeding canals, I would propose to construct one from the river Terek, the beginning of which I would place below the confluence of the rivers Terek and Malka. I would like to mention here that, scientifically speaking, the Terek and its basin, containing a much smaller quantity of water than the Malka, should be considered as an affluent of this latter, and not as geographers state that the Malka is a tributary of the Terek.

The elevation of the Terek, at the proposed opening of the canal is 530.74 feet, above the level of the Black Sea. The highest point of the Manytch lowlands above the Black Sea is 81 feet*). Consequently we have a difference of 449.74 feet, which, in 326.40 versts, the total length fo the canal, would give an inclination of 1.38 feet in the verst, or more than 0.0003. This gradient being too considerable we are bound to reduce it to 0.0002 by making 48 falls. In the case of the Jumna-Ganges Canal in India an incline of 0.0003 was at first allowed, but it was afterwards found necessary to reduce it by the making of falls. As a general rule we must calculate the speed of current for irrigating and feeding canals at not more than 4 feet per second.

From the Terek I propose to take 13.1 cubic sajens per second at low water, and 21.2 cubic sajens per second at high water; this can easily be done, as the quantity of water carried down by the Terek is from 18 to 57 cubic sajens per second, and the fall of the river, below the town of Mozdok, is not less than 0.0009**). I also propose to build, close to the village of Tchernoyarskaya, a vast basin for collecting the heavy sediments, for instance sand, as otherwise the canal could become obstructed. The passing of the water through this basin would not prevent the lighter river mud or slime from being carried on into the canal. The utility, for agricultural purposes, of this mud or slime, is obvious to all.

The dimensions of this feeding canal are as follows:

a) The Terek-Kuma Section, for Irrigation only.

Length	162.5	versts.
Transversal section:		
Width at bottom	126	feet.
Depth, at low water	9	”
” at high water	12	”
Incline	0.0002	
Number of falls, 0,75 saj. high	48	”
Volume of water per second, min.	13.10	cub. saj.
” ” ” max.	21.20	” ”

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*) According to the calculations made by the Kumo-Manytch Expedition.

**) Levelling investigations made by Mr. Petersen C. E. and Mr. Dahl, C. E.

This canal would cross the existing Eristoff Canal and the river Kura by means of two embankments, the first occurring between the 31 and 32 versts, and the second on the 68 verst. At the last mentioned place the bottom of the canal would be at a height of 66.87 sajens above the Black Sea level, and the high-water level of the Kura attains 64.42 sajens. On reaching the 132-nd verst the canal would intersect the ravine of Atcheekulak. It apprcaches the river Kuma at the village of Vladimirovka, and is conducted over this river by an iron bridge, the bottom of which would be 25.40 sajens above the level of the Black Sea, whereas the highest level attained by the waters of the river Kuma is 24.15 sajens.

b) The Kuma and Kalaus Section, for Irrigation and Navigation.

At first I purposed the continuation on this branch as an irrigation canal only. During my stay in the Caucasus I paid a visit to the village of Vladimirovka, and found that the soil was particularly fertile in that district (rich humus), that the population was comparatively dense, most of the settlements having several thousands of inhabitants, but that there was great necessity for cheap means of communication. I therefore decided to project a navigation canal, in order to give an outlet to the produce of this rich, but distant country. I calculate the dimensions of this canal to be as follows:

Length	163.9	versts.
Transversal section near the river Kuma:		
Width at bottom	105	feet.
Depth, at low water	10.5	„
„ at high water	13.5	„
Incline	0.0001	
Number of sluices, with a fall of 0.75 saj	5	
Transversal section near the river Kalaus:		
Width at bottom	98	feet.
Depth, at low water	10.5	„
„ at high water	13.5	„
Volume of water per second, min.	9.47	cub. saj.
„ „ „ max.	14.14	„ „

The total length of the Terek-Kalaus feeding canal would thus be 326.44 versts.

In comparing the two sections of this feeding canal it will be seen that the latter navigable half has a less incline than the former. The elevation, at the beginning of the canal, being 23.65 sajens, and, at the end 10.73 sajens gives a difference of 12.92 sajens. One part of this difference would be removed by five locks, and the other would form an incline of 0.0001. The

Navigation Canal, after having crossed the Kuma, runs parallel to the course of this river, then turns, almost at a right angle, to the northwest, crosses the rivers Tchograi, Hulva, Irbill and Kalaus, and reaches the watershed of the Manytch opposite to the island of Taikul. In calculating the volume of water necessary to supply this canal, I have taken, as a basis for irrigation purposes, the calculations made by Mr. M. N. Gerssevanoff, viz: — 1/20,000 cubic sajens per second on each dessiatina of land, equal to 1.04 cubic sajens per second for 20,800 dessiatinas. Outlets of water are proposed into the the Eristoff canal, into the bed of the Kura, on the lands adjoining the Kuma and, close to the settlement of Aglamani, into Sukhaya Padina.

C. Branch Navigation Canal between the main Rostoff-Astrakhan Canal and Serebriakoff's Wharf.

(Suggestion of Mr. N. A. Shavroff. C. E).

This canal purposes to facilitate the communication between the Volga and the Caspian as, firstly, Serebriakoff's Wharf is considered a more convenient place for the transfer of cargoes from river to sea ships; and secondly, because the bar of the Volga has three feet of water, and, indeed sometimes only two feet. But these two circumstances wonld not be sufficient to prove the necessity of this Canal as the existing anchorage ground in the Volga is sufficiently secure, and the deepening of the river's bar can easily he accomplished by dredging. But the main object of this canal would be to connect the Black Sea with the Sea of Azoff, by way of the western section of the main Rostoff-Astrakhan Canal.

The following would be its dimensions:

Length	117.77	versts.
Transversal section:		
Width at bottom	70	feet.
Depth of water	10.5	„
Incline	0.000016	
Number of sluices, with a fall of 1,20 saj.	4	
Volume of water per second	2.78	cub. saj.

Before entering into a description of the proposed Kuban canal, I must say a few words on the irrigation of that part of the country through which the Terek canal would pass. It is a well known fact that the waters of the river Kuma, instead of flowing on into the Caspian, are lost in the desert, and it was generally admitted that, for the purposes of irrigation, the quantity of water in it should be increased. To accomplish this it has even been proposed to divert the Malka from its natural course, and to conduct its stream through the valley of the river Zolka into the Kuma. The current of the Kuma, near the village of Bourgon Madjari attains two cubic sajens per second, but beyond Vladimirovka the water passes over perfectly level ground, and even ten cubic sajens per second would not suffice to cause its flow on to the Caspian Sea, unless the shores of the river were banked and its general flow regulated.

For this reason I propose to irrigate the plains adjoining the Kuma not by utilizing its bed, but by means of separate canals and ditches, branching off from the Terek feeding-canal, and not allowing the canal's waters to run into the Kuma itself.

It will be seen from my former statements that the transversal sections of the canals have been projected to answer the two purposes of Navigation and Irrigation.

To regulate the quantity of water necessary for both of these purposes I propose the construction of a series of falls. The sediment basin before referred to, will collect the sand and gravel, and the water will pass on retaining only the light and fertilizing mud. I calculate the necessary volume of water during the hot season of the year, at 21.20 cubic sajens per second, of which 9.47 cubic sajens are reserved for navigation, and 11.73 cubic sajens for irrigation. This will provide irrigation for 234600 dessiatinas*), or 2234 square versts. Calculating that each square verst affords means of subsistence for 100 persons, we would thus provide for the maintenance of 223400 persons. Irrigation causes the value of land to increase enormously, as we see, for instance, in France, on the river Durance where formerly a dessiatina of land could he purchased for fifty roubles, whereas it is at present valued at 3000 roubles. In the Northern Caucasus the general price of land is about ten roubles per dessiatina, but an irrigated dessiatina costs over 800 roubles.

D. The Kuban-Manitch Canal.

This canal will fulfil the three purposes: — of feeding the main Rostoff-Astrakhan canal; of irrigating the adjoining lands; and of improving the navigation on a shallow part of the river Kuban. I propose to begin this canal at a place below the mouth of the Ooroop, a tributary of the Kuban, and situated at 520.38 feet above the level of the Black Sea. We could have commenced the canal at a point above the mouth of the Ooroop, and irrigate the valley of the Yegorlick*). But, in that case, the quantity of water at our disposal would have been much less, — namely 7 instead of 11.77 cubic sajens per second. The main portion of this canal runs to the Manytch, and a branch of it to the settlement of Ladovskaya, on the Kuban.

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*) 11.73 × 20,000.

The following are the proposed demensions of this canal.

a) Feeding canal, from the mouth of the river Ooroop to the settlement of Grigoripolisskaya, on the right bank of the Kuban.

Length	72.5	versts
Transversal section:		
Width at bottom	85	feet
Depth, at low water	8	„
„ at high water	11	„
Incline	0.00022	
Volume of water, min.	13.69	cub. saj.
„ „ „ max.	7.50	„ „

b) Navigation Canal from the settlement Ggigoripolisskaya, over the Kuban, along its left bank down to the settlement of Ladovskaya.

Length	87	versts
Transversal section:		
Width at bottom	70	feet
Depth of water	8	„
Incline	0.000016	
Number of sluices, with a fall of 1,20 saj.	42	
Volume of water per second	1.94	cub. saj.

The level of the Kuban, at the settlement of Ladovskaya is 106,68 feet above the Black Sea.

c) Navigation Canal from the settlement of Grigoripolisskaya to the settlement of Rasshevatskaya.

Length	90	versts
Transversal section:		
Width at bottom	70	feet
Depth of water	8	„
Incline	0.00008	
Volume of water per second	5.56	cub. saj.

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*) Project of Mr Agapoff.

d) Navigation Canal from the settlement of Rasshevatskaya to the village of Beloglinskaya.

Length	121	versts
Transversal section:		
Width at bottom	70	feet
Depth of water	8	„
Incline	0.00005	
Number of sluices, with a fall of 1,20 saj.	16	
Volume of water per second	3.07	cub. saj.

e) Navigation Canal from the village of Beloglinskaya to the village of Novo-Manytchskoe.

Length	113.274	versts
Transversal section:		
Width at bottom	70	feet
Depth of water	8	„
Incline	0.000016	
Number of sluices, with a fall of 1,20 saj.	29	
Volume of water per second	1.04	saj.
The total length of the Kuban-Manytch canal would be	483.777	versts.

The distribution of water for navigation and irrigation is calculated in the following manner. The total volume of water at our disposal is 13.69 cubic sajens per second; for navigation on section b. we require 1.94 cubic sajens, and for navigation on sections c., and e., 3.07 cubic sajens per second will be required, the total amounting to 5.01 cubic sajens. Subtracting this quantity from 13.09 cubic sajens, the amount of water left at our disposal for irrigation will be 8.68 cubic sajens. This would irrigate 173,600 dessiatinas*), or 1653 square versts, this land being able to support, at the rate of 100 persons per square verst, 165,000 persons.

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*) 8.68 × 20,000.

Conclusion.

TOTAL LENGTH. 1) The feeding canal Terek-Kalaus, 326.4 versts, of which 163.9 will be for navigation.

2) The feeding canal Kuban-Manytch, 483.77 versts, of which 411-27 will be for navigation.

3) The Navigation canal Rostoff-Astrakhan, 755.08 versts.

4) Branch navigation canal to the Serebriakoff Wharf 117.77 versts.

Total length of the Canal System 1,683 versts, of which 1,449 are intended for navigation.

IRRIGATION AND COLONISATION. By allowing one cubic sajen of water per second for each 20,000 dessiatinas of land the total extent of territory which could be irrigated is as follows:

by the Terek-Astrakhan canal..............	2234	sq. versts;
„ „ Kuban-Manytch canal................	1653	„ „
Total	3887	sq. versts.

Thus we may safely state, in round numbers, 4000 square versts or 400,000 dessiatinas which could be colonized by 400,000 persons.

TOTAL OUTLAY. The cost of constructing these canals has been calculated at the rate of R. 45,000 per verst, thus the total sum required would by R. 65,735,000. The income to be derived from navigation, as well as from the use of the water at the falls is very difficult to estimate; the irrigation, however, would considerably increase the value of land. Thus, calculating at an average of 200 roubles per dessiatina, the increase of value of the irrigated lands would alone amount to the sum of R. 80,000,000*).

GENERAL-CONSIDERATIONS. Many useful schemes have been put forward for the canalization of the various districts of the Northern Caucasus; as for instance N. Shavroff, C. E. proposed an open canal between the Volga and the Serebriakoff Wharf in order to avoid the crossing of the Volga bar; D. J. Romanoff, C. E. proposed the plan of irrigating the Terek district; Mr Jarinzoff formed the plan of facilitating the navigation of the Kuban. Further propositions have been made for directing the waters of the Terek into the river Kura, and into the Eristoff Canal, also for constructing an open sea canal between the Caspian and the Sea of Azoff. But each projector had his particular object in view irrespective of the others, without considering either the needs of the outlying districts, or the claims of the country at large. In acknowledging the utility of these various schemes, I have endeavoured to embody them into one grand system of canals.

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*) 400.000 × 200.

I do not profess to be a specialist in State Economy, but I think that the combination of all these canals would enormously increase the productiveness of great tracts of land, would impart new life to this backward country, facilitate the means of communication, and throw open the world as a market for its produce.

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TABLE OF DIMENSIONS.

Table of

	Length.	Width at bottom.
	Versts.	Sajens.
Sea canal.		
1) From Astrakhan to Serebriakoff Wharf	284.77	10
From the Terek.		
2) From the Sea canal to the Manytch watershed......	225.89	9
3) From the Manytch watershed to the Don...........	362.20	9
4) From the Manytch watershed to the river Tchograi..	55.07	14
5) From the Tchograi to the Kuma.................	108.84	15
6) Feeding canal from the Terek to the Eristoff canal..	32	18
7) „ from the Eristoff to the river Kura	38	17
8) „ from the Kura to Sukhaya Padina	27	16
9) „ from Sukhaya Padina to the river Kuma ...	65.50	15
From the Kuban.		
10) From the village Grigoripolisskaya to the vill. Ladoffskaya	87.50	10
11) From the vill. Grigoripolisskaya to the vill. Rasshewatskaya	89.60	10
12) From the vill. Rasshewatskaya to the river Manytch.	234.63	10
13) The Kuban feeding canal.........................	72.50	12.15
14) Total.......	1683.026	—

limensions.

Low Water.			High Water.			Number of sluices.	Number of falls.	Incline.
Depth.	Speed.	Quantity per second.	Depth.	Speed.	Quantity per second.			
Feet.	Feet.	Cub. saj.	Feet.	Feet.	Cub. saj.			
10½	1	2.78	—	—	—	7	—	0.000016
10½	2.28	5.85	—	—	—	9	—	0.00008
10½	1.37	3.52	—	—	—	7	—	0.00003—0.000016
10½	2.60	9.47	13½	2.83	14.14	2	—	0.0001
10½	2.62	10.11	13½	2.86	15.03	4	—	0.0001
9	3.47	13.11	12	3.99	21.20	—	2	0.0002
9	3.45	12.40	12	3.97	20.15	—	1	
9	3.42	11.38	12	3.95	19.22	—	2	
9	3.40	10.00	12	3.94	18.02	—	43	
8	0.99	1.94	—	—	—	42	—	0.000016
8	2.92	5.56	—	—	—	—	—	0.00008
8	1.53	3.07	—	—	—	45	—	0.00005—0.000016
8	3.18	7.50	11	3.92	13.69	—	—	0.00022
—	—	—	—	—	—	—	—	—

Table of Russian and English measures.

1 verst = 500 sajens = 3500 feet = 0,6629 of a statute mile.
1 sajen = 7 feet.
1 dessiatina = 2400 square sajens = 2,6999 English acres.